

DEPARTMENT OF PHYSICS UMBC
PHYS 122L: Introductory Physics Laboratory

Dr. Daniel Gonzales

Spring 2024

E-mail: DPGonzales@UMBC.edu

Office Hours: W/Th 1:00 pm PHYS 226A

Lecture: M 1:00 - 1:50 pm PHYS 201 §2,3

Office: Physics 324

& Tu 1:00 - 1:50 pm PHYS 201 §5,6

Course Description

This 3-credit lab course is based on the physical phenomena associated with the PHYS 121-122 lecture-course sequence. The laboratory includes planning a measurement, setting up and working with equipment, and recording data. Students will learn to analyze data, compare theory with experiment, and estimate and report errors. Students will learn to present results in a complete, concise, and clearly written report.

Learning Objectives

In this course, you will learn how to apply the tools of statistics and error propagation to quantify the results of physical experiments that you will perform. Most of the physical phenomena explored in these experiments will have been introduced to you in Physics 121 and 122. The following are the learning objectives associated with this course:

- Explain the difference between systematic and random error
- Explain what instrumental limit error is and calculate it for digital and analog scales
- Report the measured value and uncertainty for a measurement
- Describe how many significant figures are associated with a measured value
- Statistically analyze a data set to determine the weighted mean; standard deviation; standard deviation of the mean; and total uncertainty
- Apply the principles of error propagation to determine uncertainties
- Graph data sets which should include: a title, labeled axes with correct units, error bars, best fit line, and equation for best fit line

- Perform a least squares fit for a data set to determine: slope and y-intercept of best fit line, uncertainty of the measured y-values, and the uncertainties of the slope and y-intercept
- Linearize a data set and perform the same least square fit analysis as above
- Make a quantitative comparison of an experimental result with a theoretically acceptable value

The rest of the semester will be spent on applying the theoretical principles your learning from PHYS 121/122 to experiments in the laboratory. The learning objectives associated with the experiments are:

- Observe physical phenomena familiar from your lecture courses. Become familiar with the intricacies of working in a lab, such as how to plan a measurement, how to set up and use equipment, and how to take and record data.
- Learn how to analyze your data and compare theory with experiment.
- Learn to present your results in the form of a written report and presentation. (In the real world your work is usually judged by what you write about it: you prepare a report for your manager in industry, a dissertation as a graduate student, a research paper in academia. Fair or not, a badly written reports is dismissed, no matter how great the work itself would be otherwise.)

It is absolutely OK to not understand some of the terms in the above learning objectives. We will of course cover some of these new topics in depth in the lectures.

Required Textbook

The required textbook is **An Introduction to Error Analysis** by John R. Taylor. The most recent edition is the third edition and is the “required” edition. However, I will be preparing my material from the 2nd edition is very good and only missing one advanced topic on Bayesian statistics from the 3rd edition that will not be covered in this course. I found some physical copies of the 2nd edition online for as low as \$20. Digital copies are acceptable.

Taylor, is a very good book on statistical analysis. I have used it as a reference many times in my professional and academic careers. For students working towards careers in science and engineering, it is a good one to have on your bookshelf.

Prerequisites/Corequisites

Completion of PHYS 122(H) with C or higher or concurrent enrollment. You should have a good working knowledge of equations and concepts from PHYS 121 & 122 as well as knowledge of calculus (derivatives & integrals), trigonometry, geometry, and algebra.

Instructional Team

- **Instructor:** Daniel Gonzales: DPGonzales@UMBC.edu
- **TAs:**
 - Ashlyn Wright: ashlynw1@umbc.edu
 - Yasir Sarkar: ysarkar1@umbc.edu

Course Structure

This course is designed to be taken *in-person* and is *not* a hybrid or remote course. All lectures will be held in person.

Weekly Schedule

- **Lectures:** All lectures will be held in PHYS 201.
 - §4,5 M 1:00 - 1:50 pm
 - §2,3 Tu 1:00 - 1:50 pm
 - Instructor-led sessions whereby new material is presented. You are expected to have already done the reading.
- **Labs:** All labs will be held in PHYS 110.
 - §4 M 2:00 - 5:00 pm
 - §2 Tu 2:00 - 5:00 pm
 - §5 W 2:00 - 5:00 pm
 - §3 Th 2:00 - 5:00 pm
 - TA led sessions whereby students will perform their physical labs.
- **Office Hours:**

All office hours will be held in the Physics Tutorial Center in PHYS 226A. Additionally, students are free to seek help from the tutorial center at any time, not just when the instructor, Ashlyn, or Yasire will be there. The hours of operation for the tutorial center are: Monday through Thursday, 12 noon to 5 pm.

 - Ashlyn: Monday 12-1 pm, Thursday 1-2 pm
 - Yasir: Wednesday 12-1 pm, Thursday 3-4 pm
 - Additional appointments may be made with the instructor or TAs as needed.
- **Weekly Due Dates** See the **Tentative Class Schedule** section for details.
 - Pre-lab questions labeled with a “B” in the lab manual will be due at the beginning of your lab session.

- All labs will be due the Friday *after* the week they are performed at **5:00 pm**. To make it more clear, each student will have *at least* one full week to finish their lab report after the experiment is performed in the lab. The *only* exception is the first week's exercise. They are *not* due at midnight. Students are encouraged to normalize reasonable working hours for their academics.

Working in the Lab

Labs will be in Physics 110. No food or drink allowed in lab. Ordinarily, you'll work with one lab partner. Be on-time; at the beginning of lab, there's typically a ~5-minute orientation to the apparatus that you shouldn't miss. Additionally, some labs may require the whole lab period to complete. Late penalties can be applied to the grade for a particular lab in the following manner: up to 15 min late: 10%; 15-30 min late: 20%; 30 min+ late: too late to participate (possible makeup lab with appropriate excuse.) You will access the lab manual on Blackboard. You must record all your data, observations, calculations, and any variations from the standard procedure. Before leaving lab, you must have either the TA or instructor check you out to make sure you have collected all the correct data. They will also check to make sure your lab station is clean and tidy. Some short analysis will be done during the lab. However, you'll complete most of your data analysis after lab. If you finish a lab early, it may be worthwhile to begin the deeper analysis during the lab period. It's easier to get help, and you might realize you missed some important data needed in your analysis.

Analysis Reports

For all labs you will be submitting an analysis report which will include all the important elements of lab reports such as reporting data, discussion of results, and error analysis. The format is not as strict as a formal lab report and will be more like a series of questions you'll need to answer for each lab. More details on analysis reports will be provided.

In total, there will be eight labs throughout the semester. Analysis reports from these labs will be worth a total of 70% of your instructor assigned grade.

Lab Reports

There will be two full lab reports due as part of your grade.

The first lab report will be due around the midpoint of the semester. You will write a full lab report based on one of the labs you have done up until that point. For each lab prior to the due date of the full lab report, you will write a single section from a hypothetical full lab report on that lab. For instance, during the first lab of the semester, you may be asked to write a conclusion section for that lab. This full lab report will worth 10% of your instructor assigned grade.

The second lab report will be based on your independent investigation (more on this below). This lab report will be worth 50% of your final project grade. Your final project grade will be worth 20% of your instructor assigned grade.

Reports must be typed using a word processor and should conform to the format supplied in the sample lab report. It must be spell-checked and written in clear English. (Publishers return manuscript without review, if language is full of errors.)

You may talk to your classmates and lab partner regarding the lab reports, but each of you must submit your own original text, graphs, analysis, and report. Copying someone else's work is cheating.

Refer to Lab Report Grading Guide under Course Materials in Blackboard for detailed grading criteria. Here are some of the important elements:

- All analysis detailed in the lab manual
- All conceptual questions are answered in the analysis/conclusion
- "Quality of language" means it is objective, precise, and concise (in addition to being proper English). Avoid rambling and vague phrases like "human error"
- Logical organization and flow
- Error evaluation in your report
- Apply what you learned in lecture– always include error, correct sig figs, etc.
- Describe the error method: "s.d. of mean", "added in quadrature", "I used ___ function in ___ program"
- In the APPENDIX, include error propagation formulas (esp. ones that use partial derivatives). You can also attach Excel tables (printed out or pasted in). If you do some extended analysis, derivations can go here, too.
- ILE can usually be stated once: "All values in this table..."
- Figures and tables
- No ambiguity– include labels, captions and units!
- When plotting data, it should come with error bars. This can be individual measurement error, or it can be error from the least squares fit (Z parameter). Always specify.

Late/Early Policy

Each student is allowed to turn in two lab assignment up to 48 hours late without penalty. For each assignment, the student needs to email the instructor (and copy the TAs) **before** the assignment is due.

The first late assignment will be no questions asked from the instructor. To not earn a penalty on the second assignment, the student must schedule a 10-minute meeting with the instructor to discuss what underlying issues might be preventing the student from completing their assignments on time. This meeting is only meant to *help* the student. It is not meant to shame the student or make the student feel guilty for turning in late assignments.

Students are free to turn in their assignments as early as they like. Any student that turns in an assignment more than 24-hours in advance of the due date, and earn an extra 48-hour no-penalty-extension to another assignment.

Any late assignment not covered by a no-penalty-extension will incur a 50% deduction in points if turned in within 48-hours of the deadline. Any assignment that is more than 48-hours late will earn a 100% deduction in points.

Make-up Lab Policy

Deadlines for assignments are firm, and the above late penalties will be applied for late submissions. However, please let me know as soon as you can of any documented extended illness or family responsibilities that may impact your ability to keep up in the class, and we'll try to make a plan to keep you on track to succeed! There is a makeup week for labs near the end of the semester.

If you know in advance that you will miss a lab session due to a scheduling conflict, you may be able to make up the lab the same week. You **MUST** inform the instructors and TAs at least 24 hours in advance of missing your assigned lab session *and* be able to attend a different lab session that same week. If you are unable to come in that week, there will be one week toward the end of the semester where any student can physically perform a missed lab. This lab will be considered late, but can be granted a penalty-free-extension per the late policy above.

Final Project

Most of the semester, you'll be performing measurements and analysis which we prescribe for you, and for which the expected outcome is known. In contrast, you'll spend the last few weeks of the semester in uncharted waters, designing and carrying out an investigation on a topic of your own choosing.

This project is worth a total of 30% of your final grade. This is a team project, and for the most part, the grade on this project will be shared by all students in the group. However, the instructor reserves the right to adjust these points for egregious instances of asymmetrical work and/or communication within the group. The final project must be complete for a student to earn a passing grade in the course.

The Elements of your independent investigation include:

Informal Proposals: This proposal is a way to let the instructor know what you plan to do. The informal proposal should be a couple of paragraphs and describe what physical concept you would like to test. It's best to give as much detail as possible on how you would like to perform this project. However, if you are mildly vague about what you want to do, that is OK. The informal proposal is worth one of the thirty percentage points for the final project.

After you submit your informal proposal, the instructor will meet with your group to get a better understanding of what you want to do. They will help the group come up with a more concrete idea for an experiment to perform.

Formal Proposal: After meeting with the instructor after submitting your informal proposal, you will be required to submit a formal proposal. This proposal should convey a clear idea of what you want to test, the relevant physical theory/equations, how you will perform the experiment, and what materials you will need to perform the experiment. This proposal is worth four of the thirty percentage points for the final project grade.

Written report: Same as a regular full lab report that you'd submit in week 9. Worth 15 of the 30 percentage points for the final project.

Presentation: 10 min presentation (8 min for your presentation, 2 min for questions). Motivate the question you asked, describe how you designed your experiment, and summarize your results and analysis. Include any lessons learned that you might apply next time. Worth 10 of the 30 percentage points for the final project.

Some general criteria: It doesn't matter how close you come to resolving the question you

ask of nature – much more important is the process. Do you make a convincing case that your question is interesting and worthwhile? Do you make some use of the elements of planning measurements or data analysis that you've learned? Did you take advantage of feedback you received during planning? Do you show evidence that you've shared the work – taken the lead on some aspects, while checking on those aspects your partner has led?

Grading Policy

The standard 10% per letter grade scheme will be used. Below will be the following breakdowns with S being the final score for a student in the class.

A	$S \geq 90\%$
B	$90\% > S \geq 80\%$
C	$80\% > S \geq 70\%$
D	$70\% > S \geq 60\%$
F	$60\% > S \geq 60$

The instructor reserves the right to curve the scale depending upon on overall class scores at the end of the semester. Any curve will only ever improve a student's grade.

The grade will count the assessments using the following proportions:

- **60%: Labs**
 - The instructor will drop the student's lowest earned score at the end of the semester. The instructor will *not* drop a zero resulting from an assignment that is not turned in, however they will drop a zero that results from a *late* assignment.
- **30%: Final Project**
 - **15%: Lab Report**
 - **10%: Presentation**
 - **4%/1%: Formal and Informal Proposal respectively**
- **10%: Independent Investigation**

All scores will be posted to Blackboard. It is the student's responsibility to check Blackboard to make sure that their grades are correct. If there are any errors, the student must contact their TAs immediately to resolve the problem. All posted scores become final one week after they are posted.

Technology Use:

UMBC requires all students to be technologically self-sufficient, which entails having a **reliable personal computer** (preferably a laptop with webcam) and **Internet access**. Since UMBC requires all students to have a computer and Internet access, financial aid may be used to meet this requirement. To learn more, students should contact their financial aid counselor at financialaid.umbc.edu/contact. In addition, the Division of Information Technology (DoIT) provides a wealth of resources and support, including tips for getting online and minimum specifications to consider when purchasing a computer (doit.umbc.edu/students).

- **Blackboard:** Assignments, class slides, lab notes, and announcements will be posted on Blackboard as well as your grades. It is your responsibility to keep up to date with the course materials and announcements posted on Blackboard.
- **Microsoft Word and Excel:** These programs are available for free to download as a UMBC student. The necessary features are available in desktop application version. **At some point, we will learn how to plot data with error bars. This is surprisingly difficult, if not impossible, with other spreadsheet applications, including the browser based version of Excel. You are free to use any spreadsheet application you want, but the instructional team cannot offer support for making plots in other applications. You'll be on your own.** Sorry for the bold font in the previous statements. I'm not trying to shout or be stubborn or inflexible. It really is just *that* difficult to make error bar plots in non-Excel applications. If your data evaluation required the use of a spreadsheet, attach it to your lab report. Incorporate only the main results and plots in the main text of the report.
- **Webex:** Options to meet with the TAs and/or instructor via Webex will be available. If for any reason we need to move to a fully remote course, Webex will be used for lectures and office hours. If this happens, details regarding the move to a fully remote course will be communicated to all students.

Academic Integrity and Honesty

All instances of academic misconduct will be addressed according to the UMBC Policy on [Academic Integrity](#). Examples include attempting to make use of disallowed materials on assignments, soliciting help by posting material on the internet for any assignment, looking at posted material from others online, altering graded work and submitting it for regrading, asking someone else to take an assignment in your place, copying another's work on an assignment, asking someone else to do an assignment and representing it as your own, permitting or assisting another student to carry out any of the above, or any other instance of academic misconduct. Penalties range from a grade of 0 on the assignment to an F in the course (at my discretion), and from denotation of academic misconduct on the transcript to expulsion (as determined by official hearing of the Academic Conduct Committee).

It is my firm belief that no student enrolls in a course with the intention of cheating their way through it. Rather, as a course progresses and a student falls behind their goals, they see cheating as a desperate resort to get back on track. If you find yourself in this situation, please reach out for help from the instructor and TAs. Every one of you can pass this course with resorting to cheating, let the instructional team help you out if you feel overwhelmed.

Contacts

- Contact your TAs with questions regarding grades or for general help.
- Contact the instructor, Daniel Gonzales (DPGonzales@UMBC.edu), for anything not satisfactorily handled above, complaints about TA performance or behavior, final grade inquiries, or suggestions for improvements to the lab curriculum.

- Please cc both TAs and the instructor on all emails, unless the subject is of a personal or private nature.

Tentative Course Schedule

Week Date	Lab Activity Lecture Topic: Reading	Assignment Due	Final Project Due
1 1/29	Excel Lab Uncertainties & Errors: Taylor Chs 1 & 2		
2 2/5	Statistics Lab Error Prop. & Statistical Analysis: Taylor Chs 3 & 4	Uncertainties Lab	
3 2/12	Least-Squares Fitting Taylor Ch 8	Statistics Lab	
4 2/19	A: Atwood's Machine B: Ballistic Pendulum Lab Manual	Linear Regression Lab	
5 2/26	A: Ballistic Pendulum B: Atwood's Machine Weighted Statistics: Taylor Ch 7	Week 4's Lab	
6 3/4	A: Simple Harmonic Motion B: Angular Momentum Lab Manual	Week 5's Lab	
7 3/11	A: Angular Momentum B: Simple Harmonic Motion The Normal Distribution: Taylor Ch 5	Week 6's Lab	
3/18	Spring Break, No Class/Lab The Hitchhiker's Guide to the Galaxy	Take it Easy Or don't, you do you	
8 3/25	A: Thermal Lab B: e/m Ratio Lab Manual	Week 7's Lab	Informal Proposal
9 4/1	B: e/m Ratio Thermal Lab To Be Determined	Week 8's Lab Full Lab Report*	
10 4/8	A: The Current Balance B: DC Circuits Lab Manual	Week 9's Lab	Formal Proposal
11 4/15	A: DC Circuits B: The Current Balance Giving a Technical Presentation	Week 10's Lab	
12 4/22	Make-Up Labs To Be Determined	Week 11's Lab	Prototyping
13 4/29	Project Experiments	Make-Up Lab	Execution
14 5/6	Project Presentations	Presentation Slides & Report	Due Monday at Noon
15 5/13	Project Presentations (as needed)		

* The full lab report will be written about one of the first four labs. The student is free to choose any of those labs to write about. It is *not* meant to be based on week 8's lab.

Accessibility and Disability Accommodations, Guidance and Resources

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that create equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at sds.umbc.edu for registration information and office procedures.

SDS email: disAbility@umbc.edu

SDS phone: 410-455-2459

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination

[UMBC Policy](#) in addition to federal and state law (to include Title IX) prohibits discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment, or related retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources. The Title IX Coordinator can be reached at titleixcoordinator@umbc.edu or 410-455-1717.

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in making a report, please use the [Online Reporting/Referral Form](#). Please note that, if you report anonymously, the University's ability to respond will be limited.

Notice that Faculty and Teaching Assistants are Responsible Employees with Mandatory Reporting Obligations

All faculty members and teaching assistants are considered Responsible Employees, per UMBC's [Policy on Sexual Misconduct, Sexual Harassment, and Gender Discrimination](#). Faculty and teaching assistants therefore required to report all known information regarding alleged conduct that may be a violation of the Policy to the Title IX Coordinator, even if a student discloses an experience that occurred before attending UMBC and/or an incident that only involves people not affiliated with UMBC. Reports are required regardless of the amount of detail provided and even in instances where support has already been offered or received.

While faculty members want to encourage you to share information related to your life experiences through discussion and written work, students should understand that faculty are required to report past and present sexual harassment, sexual assault, domestic and dating violence, stalking, and gender discrimination that is shared with them to the Title IX Coordinator

so that the University can inform students of their rights, resources, and support. While you are encouraged to do so, you are not obligated to respond to outreach conducted as a result of a report to the Title IX Coordinator.

If you need to speak with someone in confidence, who does not have an obligation to report to the Title IX Coordinator, UMBC has a number of [Confidential Resources](#) available to support you:

[Retriever Integrated Health](#) (Main Campus): 410-455-2472; Monday – Friday 8:30 a.m. – 5 p.m.; For After-Hours Support, Call 988.

[Center for Counseling and Well-Being](#) (Shady Grove Campus): 301-738-6273; Monday-Thursday 10:00a.m. – 7:00 p.m. and Friday 10:00 a.m. – 2:00 p.m. (virtual) [Online Appointment Request Form](#)

Pastoral Counseling via [The Gathering Space for Spiritual Well-Being](#): 410-455-6795; i3b@umbc.edu; Monday – Friday 8:00 a.m. – 10:00 p.m.